FREE BLUEPRINT: Build a hydrofoil boat in two weekends—for $116!

POPULAR SCIENCE

MAY · 35c *Monthly*

Silent Engine

can bring quiet mowers, outboards, home generators

PAGE 110

LET'S ABOLISH STUPID SPEED LIMITS! PAGE 65

Copyrighted material

By Harry Walton

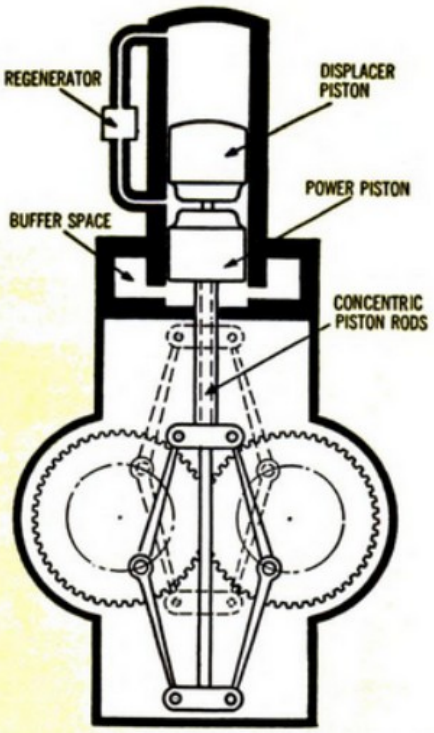
A DIFFERENT kind of one-lung engine is headed your way. Some day you may get into a boat, put a match to a burner, twist the engine shaft over dead center, and glide *silently* out to catch the big ones.

That same engine could give us hushed power mowers, quiet-running home electric plants, and even muffled cement mixers or chain saws. But its first job may well be in outer space —to drive electric generators in orbiting satellites.

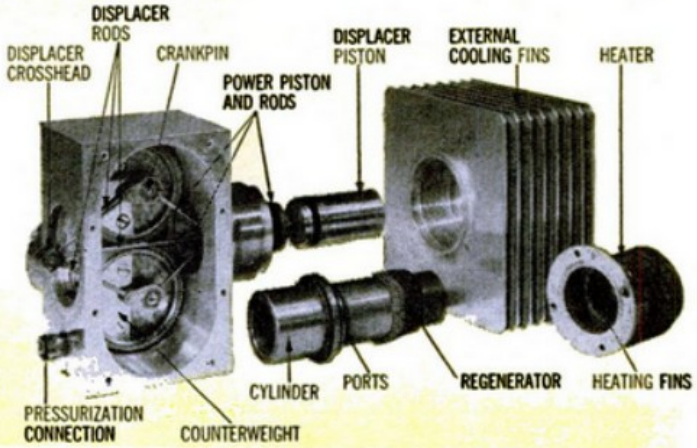
It's the hot-air engine, updated by modern research and a gee-whiz con-rod system like none you ever saw. This faithful old-timer now beats the diesel, the gasoline engine, even the gas turbine, in efficiency. In this jet age, it puts the piston engine back in the running.

As tomorrow's outboard or mower engine, it ducks many griefs built into gasoline putt-putts. It has no carburetor, ignition, spark plug, or valves. Having no exhaust, it needs no muffler. Even in one-cylinder form, it is vibration-free. You can run it on gas, kerosene, fuel oil, or burning straw. It can be compact, delivering up to *two* horsepower per cubic inch of piston displacement.

Heat is the muscle power. A diesel



DISPLACER must lead the power piston by about 110 degrees to key the working cycle properly. This diagram of the rhombic drive shows how such crank displacement is achieved. The degree of displacement can be altered by changing spacing between the shafts, or by fitting offset links to the crankpins. Because the pistons work in tandem, the displacer rod must pass through the power piston. A buffer space keeps high working pressure out of the crankcase, while maintaining it on the underside of the power piston. This lessens the work of the compression stroke; compression ratio is only 2.5:1, far less than in a gasoline engine.



DISMANTLED MODEL ENGINE at right shows the rhombic drive with its twin crankshafts. Fins inside the heater and cooler speed heat transfer. Working air flows from inside the cylinder through annular ports, passes over the outside of the cylinder past the internal cooler fins, through the wire regenerator, and picks up heat from heater fins as it returns to the top of the cylinder.

CONTINUED

Copyrighted material

locomotive compresses a cylinderful of air while it is cool, introduces fuel, and sets it afire when the piston is at top dead center. The violently heated air expands, driving the piston down. That's internal combustion, but it's the expanding hot gases that do the work.

A Scottish minister named Robert Stirling got the idea of heating and cooling the air in a closed container, kept hot by an external fire at one end and cool by a water jacket at the other. His engine, invented in 1827, shoved the air from one space to the other by moving a loose-fitting piston. A second, close-fitting work piston was pushed in while the air was cool. Heated, the air expanded and drove this piston out.

The engine worked. But it was very heavy for the power it put out. It wasted fuel; the heat the air absorbed in expanding had to be thrown away to let it contract. Efficiency was about five percent.

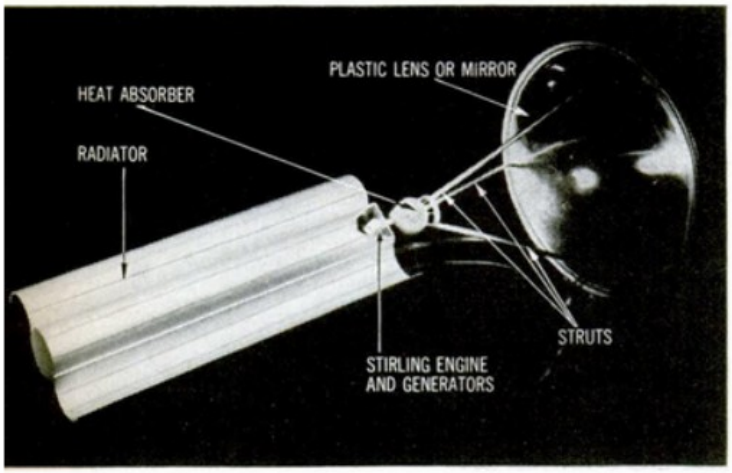
This inspired Stirling to add the regenerator, a chamber of fins through which the air passed between the hot and cold spaces. Coming from the hot space, it gave up heat to the fins. Returning from the cold, it took heat back from the fins.

Further improved by others, the hot-air engine went to work in a power-hungry world.

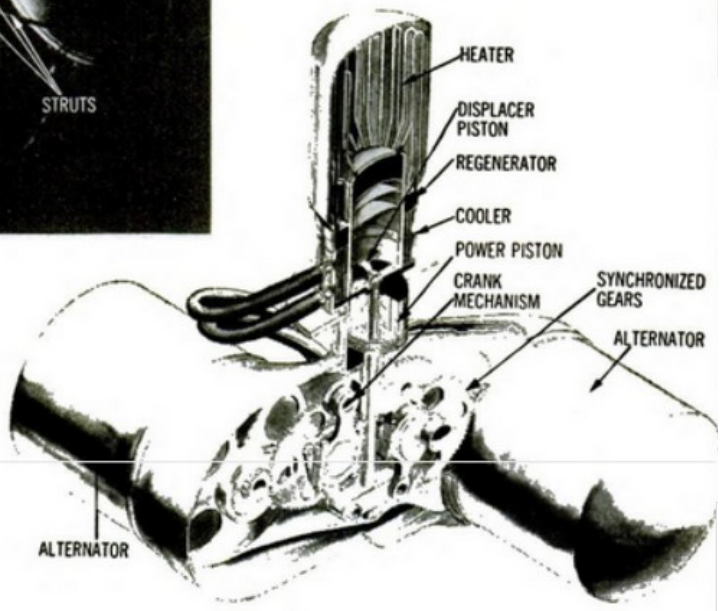
John Ericsson, builder of the Civil War Monitor, developed what he called his "caloric" engine. It differed somewhat from Stirling's—the pressure of the air instead of its volume remained constant as the air passed in each direction through the regenerator. By 1833, he was deep in experiments with marine application.

Ericsson put a four-cylinder engine into a Navy vessel. Its 14-foot pistons developed 300 hp. Other Ericsson engines went into riverboats. Smaller ones pumped water, and tiny alcohol-fired ones turned fans. But with the development of the electric motor, steam and internal-combustion engines, Stirling's engine became a museum piece.

Wanted: power for generators. In 1938 the N. V. Philips Gloeilampenfabrieken, of Eindhoven, Holland, sought a means of generating electricity for radios and

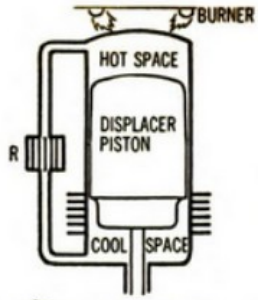


SATELLITE POWER PLANT would use solar heat to run a Stirling hot-gas engine. Sun's rays, focused on a heat absorber, melt lithium hydride, which flows through engine's heater. Coolant from engine gives up its heat to radiator, which then disperses it into space.

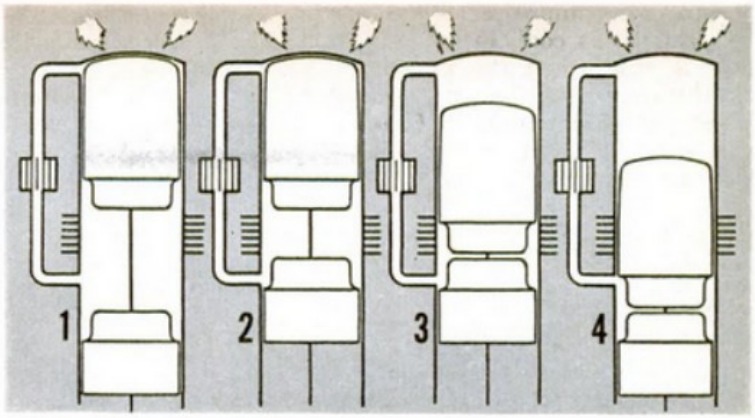


ONE-CYLINDER Stirling engine, designed for satellite power plant (right) by Allison Division is coupled to two alternators. It will generate three kilowatts. Since all rotating parts are paired and turn in opposite directions, gyroscopic effects cancel out. Entire unit will be sealed in a helium atmosphere.

Copyrighted material



HOW DISPLACER WORKS: As the displacer piston moves up, it forces all the air out of the hot space, through the regenerator (R) into the cold space below, where it contracts. As the piston moves down, it reverses the flow, displacing all the air at the bottom and forcing it into the hot space, where it must expand.



WORK RESULTS when the cylinder is lengthened and power piston added. With displacer at top, and the air in the cold space (1 above), power piston rises either by the starting turn or from flywheel momentum to position in 2, compressing the cool air. But now the displacer moves downward (3). Air entering the hot space expands, driving the power piston down. As displacer continues downward, the rest of the air is transferred, moving the power piston to the bottom of its stroke (4). The displacer now returns to position 1, repeating the cycle.

home lighting. The steam engine was too bulky, demanded too much attention. The gas engine was too choosy about fuel.

Philips dusted off the hot-air engine, applied modern knowledge of thermodynamics and heat transfer, and got an amazing answer: The hot-air engine had a *theoretical* efficiency of 71 percent, higher than that of diesel, gas engine, or turbine.

War and the Nazi occupation engulfed Philips. The canny Dutch hid research files, took names off lab doors to conceal what they were doing. In 1944 the first engine proved successful. By 1947 it was running moderately efficient generating plants. And by turning the Stirling cycle upside down, Philips created excellent refrigerating and air-liquefying machines.

But engine efficiency still lagged, until the researchers found that dead volume (the space not swept by the work piston) was critical, and that air wasn't the best working medium. Hydrogen, lightest of gases, would hold more B.T.U.s per pound, flow like a greased eel, take on and give up heat in a flash. Build an engine this way, they said, and it should have an *actual* efficiency of 36 percent.

In 1954 the engine was built. It checked out at 36 percent. Today's best aircraft piston engines are only 28 to 30 percent efficient. The diesel scores 32 to 34 percent; the gas turbine lags at 26 percent.

Updating the Stirling. What made the difference between the feeble old Stirling engine and this rugged new contender? Better materials, sophisticated heat-transfer surfaces, regenerators with 98-percent efficiency, and pressurization.

You can build an air engine that limps along on the air that seeps into it from the atmosphere. When hot, it will be slightly above atmospheric pressure; when cold, slightly below. Its power is what you might get if you moved a gas-engine piston to top dead center, let air into the combustion chamber at atmospheric pressure, squirted in fuel, and managed to fire it.

Instead, your car engine gulps a cylinderful, then compresses the charge to a fraction of its original volume before firing it. The more air you jam in, the greater the pressure rise on firing. But in gas engines, compression is limited by the critical fuel-air ratio necessary, and by antiknock considerations.

In the closed system of the externally fired hot-air engine these don't matter. The new Stirling engine works at an average pressure of 1,500 pounds per square inch, which can be maintained by a small pump. On expansion, pressure rises to 2,100 p.s.i.—not in an explosive bang, but in a smooth, steady push.

[Continued on page 240]

BALKY

MOWER?

QUICK! Speed it up fast with a few drops of 3-IN-ONE. Penetrates hard-to-get-at places. Doesn't gum up.

3-IN-ONE OIL

REGULAR · OIL SPRAY · ELECTRIC MOTOR

FRAME SPLIT?

FIX IT QUICK!

Easy! No skill required. Won't chip or crack! Nothing like it to resist water, weather!

For surest results always use GENUINE

PLASTIC WOOD

Handles like putty—hardens into wood!

PEEL PAINT OFF

Furniture | Floors | Boats | Woodwork

KLEAN-STRIP

PAINT REMOVER

Fast • Clean • Non-inflammable

THE KLEAN-STRIP CO., INC.

2340 S. Lauderdale, Memphis 6, Tenn.

Silent Engine Starts with a Match

[Continued from page 113]

Smaller than a shoe box. What pressurization does was demonstrated for me at the Allison Division of General Motors, which is developing the engine as a solar power plant. Harvey Welsh, Chief of Advanced Projects, connected a gas hose to a model smaller than a shoe box. Thirty seconds after it was lit, he flipped the shaft over. Immediately the engine began to run at about 2,000 r.p.m. Operating on air at atmospheric pressure, it drove a small generator to power a radio.

Presently Welsh turned off the gas. The engine kept running on heat stored in its walls and regenerator. Then Welsh gave a small air pump in the base a few strokes. At once the speed of the engine jumped to almost 3,000 r.p.m.—with no flame under it.

The displacer has to move about a quarter of a revolution ahead of the power piston. The ingenious rhombic drive that does this has two shafts geared together, four con rods, and two crossheads.

It has several advantages despite its Rube Goldberg appearance. It eliminates side forces on the piston rods, making it easy to achieve gas-tight gland seals. With only a straight rod emerging from the cylinder, the crankcase is easily sealed off from it and need not be pressurized. Instead, a small buffer chamber below the power piston is kept at working pressure.

But most important, this radical drive makes a perfectly balanced one-lung engine possible for the first time. By making the masses of the two pistons and their rods equal, all inertial forces can be exactly balanced with counterweights opposite the crankpins.

40 hp. with hydrogen. A whopper of a one-lunger is developing 40 hp. at the General Motors Research Laboratories in Warren, Mich. "When you put your hand on it," says Welsh, "you can hardly feel that it's running. It's the smoothest reciprocating engine I've ever known."

With hydrogen as its working fluid, that engine attains an efficiency of 39 percent, develops its 40 hp. with a piston displacement of 20 cu. in.

Licensed under Philips patents, General Motors first turned over development work to its research laboratories. Dr.

Copyrighted material

Speedy Sprayer
sprays paint
7 times faster than hand brushing!
And what a finish . . . smooth, flawless, no brush strokes. So easy —just pull the trigger. Speedy Sprayer is a real professional tool. Paints anything, toy to a house. A must for every workshop. Operates with any ¼ or ⅓ hp motor.
890 OUTFIT, less motor, $42.50
Mobile Wheel Kit, $7.50 extra
W. R. BROWN CORP.
Specialists in Portable Sprayers for 38 Years
2637 N. Normandy Ave. • Chicago 35, Ill.
Wheel it to the job!
FREE! "How to Spray" booklet and catalog. Write!

FREE ★ BOOK
CLOGGED SEWERS
REMEMBER THE COSTLY PLUMBING BILL—
Attachable Cutter Blades
Start your Business
Electric Unit Cleans pipes 3" to 12"
Chicago—May 1. Just introduced is a Free Booklet on machines which enable the Home Owner, Janitor or Factory Maintenance Man to Rod-it-himself—
Yet anyone can operate this new Rodding Tool which is whirled down the drain in a few seconds. SINKS, BATHTUBS, TOILETS, URINALS, FLOOR DRAINS, HOUSE TO STREET SEWERS can be cleared of Rags, Grease, Paper, Sand while Cutter blades can be added for removing roots. A new discovery in Swedish Music Wire gives the rod 100% more Flexibility.
Another new unit is the Miller Electric Rodder which has patented cutters that expand automatically to the size of the pipe. It will clean out heavy obstructions in pipe diameters 3" to 12". Smaller Sizes available. But now, what are these Tools worth in COSTLY PLUMBING BILLS SAVED. Tear this Ad out—and write your name and address beside it for FREE BOOKLET on Hand and Electric Units. Obey that urge. No Agent will call. A postcard will do (Chicago Phone Kildare 5-1702)
Miller Sewer Rod, Dept. PR-5, 4640 N. Central Ave., Chicago 30, Ill.

Silent Engine Starts with a Match

Charles Russell of that division first discussed the use of the Stirling engine as a satellite power plant three years ago. This project was turned over to the Allison Division under Tibor F. Nagey, Director of Research, and Harvey Welsh, section chief.

The rhombic drive is ideal for a satellite plant because of its freedom from vibration and the canceling out of all gyroscopic action (which would make the satellite cartwheel in space). Heat will be supplied by the circulation of lithium hydride, a metallic compound that melts at 1,256 degrees, from a heat-absorbing reservoir at the focus of a solar mirror or lens.

With no air to cool the fins or a circulated cooling fluid, keeping the cold space of the engine cold is more of a problem than heating. The only way to get rid of heat in airless space is by radiation. This requires a big radiating surface—218 square feet for the three-kilowatt system. Fluid coolant will dissipate its heat to this, and the surface will radiate it away.

The engine will keep working while the satellite passes through the earth's shadow—35 pounds of lithium hydride can store as much energy, in the form of heat, as 1,100 pounds of batteries.

The engine itself accounts for only 6.7 percent of the 415 pounds that is the total weight of the system. But this is lighter than any equivalent direct-conversion system. Enough silicon solar cells to yield three kilowatts, for instance, weigh 600 pounds.

Designed to run despite damage from micrometeorites, the Stirling solar power plant is expected to go for two years at least. It won't use hydrogen (a gas that eventually seeps even through steel), but slightly less efficient helium. And just to make sure the helium doesn't get away, the engine and generating unit will be packaged in one hermetically sealed case.

That silent outboard? It will be along, Welsh believes, in three or four years. Lawn mowers and other applications will come when it is possible to make the engine cheap enough to compete with the gas one-lunger. Or, perhaps, when you're willing to pay extra to let your neighbors sleep while you mow the lawn.